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Permanent pacemaker implantation after aortic valve implantation

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ABSTRACT

Aims: Conduction abnormalities are well-recognized complications following aortic valve replacement, particularly after transcatheter aortic valve implantation (TAVI). The incidence of permanent pacemaker implantation (PPI) post-TAVI remains variable, influenced by patient and procedural factors. To evaluate the incidence, clinical predictors, and outcomes associated with PPI following TAVI, with specific attention to left ventricular ejection fraction (LVEF).

Methods: We conducted a retrospective analysis of 60 patients who underwent transfemoral TAVI between 2008 and 2011. Baseline demographic, clinical, procedural, and echocardiographic parameters were compared between patients who required PPI and those who did not. Univariate and bivariate analyses were used to identify potential predictors.

Results: PPI was required in 29 of 60 patients (48.3%), with the majority of devices implanted within 72 hours post-procedure. Dual-chamber pacemakers were most commonly utilized, predominantly for complete atrioventricular block or symptomatic bradycardia associated with new-onset left bundle branch block. No statistically significant associations with PPI were found for variables such as age, sex, atrial fibrillation, ischemic heart disease, or baseline LVEF (all $p>0.05$). Trends suggesting possible associations with atrial fibrillation and mitral regurgitation did not reach statistical significance.

Conclusion: PPI remains a frequent yet unpredictable outcome after TAVI, particularly in the era of early-generation valve systems. Our findings underscore the absence of reliable clinical predictors and emphasize the need for prospective studies incorporating procedural, anatomical, and electrophysiologic markers to refine risk stratification and minimize unnecessary device implantation.

Keywords: Transcatheter aortic valve implantation, permanent pacemaker, conduction disturbances, aortic stenosis, left ventricular function

INTRODUCTION

Aortic valve diseases such as stenosis and regurgitation can compromise the cardiac conduction system, often resulting in atrioventricular block (AVB). Surgical aortic valve replacement (SAVR) and more recently, transcatheter aortic valve implantation (TAVI), have been associated with new-onset conduction abnormalities including complete AVB and bundle branch blocks.[1,2] Reports indicate that postoperative AVB requiring pacemaker implantation is not uncommon, with wide variability depending on prosthesis type and procedural factors.[3,4]

Although CoreValve devices are particularly associated with higher permanent pacemaker implantation (PPI) rates due to their self-expanding design and subannular extension, balloon-expandable valves have shown lower incidences.[2] However, results from published studies have been inconclusive in identifying consistent predictors for PPI.[3-5] Conduction disturbances may result from mechanical injury, calcification-induced stress, or direct trauma to the conduction system during valve deployment.

This study aims to evaluate the incidence and predictors of PPI in a cohort of patients who underwent TAVI, and to assess the effect of PPI on postoperative left ventricular ejection fraction (LVEF).

METHODS

The study was conducted with the permission of the Ethics Committee of Mogadishu Somalia Turkiye Recep Tayyip Erdoğan Training and Research Hospital (Date: 09.04.2025, Decision No: 1197). This retrospective cohort study included 60 consecutive patients with symptomatic severe aortic stenosis who underwent transfemoral TAVI between September 2008 and March 2011 at a single tertiary care center. All procedures were carried out in accordance

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with the ethical rules and the principles of the Declaration of Helsinki. All patients met guideline-based criteria for TAVI, including an aortic valve area <1.0 cm² and a mean transvalvular gradient ≥40 mmHg.

PPI was assessed as the primary outcome. Indications for PPI followed institutional protocols and included complete AVB, symptomatic bradycardia, and unresolved high-grade AV block. Pacemaker implantation was performed within 30 days of the TAVI procedure.

Clinical, electrocardiographic (ECG), and echocardiographic data were collected retrospectively from medical records. Baseline parameters included age, sex, comorbidities (e.g., atrial fibrillation, ischemic heart disease), LVEF, and the presence of conduction abnormalities. Post-procedural complications, including valvular regurgitation and new conduction disturbances, were also recorded.

Conduction disturbances were defined using standard WHO/ISFC criteria and included left bundle branch block (LBBB), right bundle branch block (RBBB), and various degrees of AVB.[6] Echocardiographic assessments were conducted by board-certified cardiologists according to the American Society of Echocardiography guidelines, and included evaluation of valvular function, LVEF, and chamber size. The severity of valvular regurgitation and LV dysfunction was graded semi-quantitatively.

ECG data were independently reviewed by two electrophysiologists blinded to clinical outcomes. Clinical endpoints, including PPI, were defined in accordance with the Valve Academic Research Consortium (VARC) criteria to ensure consistency and comparability.[7]

Statistical Analysis

The data analyses were conducted using SPSS version 19.0 (IBM Corp, Armonk, NY). Continuous variables were expressed as mean±standard deviation and compared using independent samples t-tests. Categorical variables were reported as frequencies and percentages, and analyzed using chi-square or Fisher's exact tests, as appropriate. Univariate and bivariate analyses were performed to identify potential predictors of PPI. A p-value <0.05 was considered statistically significant. Missing data were handled by pairwise deletion, and sensitivity analyses were conducted to validate findings.

RESULTS

The study cohort comprised 60 patients with symptomatic severe aortic stenosis who underwent transfemoral TAVI between 2008 and 2011. The mean age was 80.8±6.5 years, and 55% were female. Comorbid conditions included atrial fibrillation in 26.7% of patients, ischemic heart disease in 80%, moderate-to-severe mitral regurgitation in 31.7%, and left ventricular dysfunction (LVEF <50%) in 33.3% at baseline.

Following the procedure, PPI was required in 29 patients (48.3%), with the majority (82.8%) receiving pacemakers within the first 72 hours. Dual-chamber pacemakers were most frequently implanted and were primarily indicated for complete AVB or symptomatic bradycardia in the setting of new-onset LBBB.

Table 1 summarizes baseline characteristics of the study population. Comparative analysis between patients who required PPI and those who did not revealed no statistically significant differences in demographic or clinical variables. Specifically, there were no significant differences in age (p=0.533), sex distribution (p=0.586), presence of atrial fibrillation (17.2% in PPI group vs. 35.5% in non-PPI group; p=0.110), ischemic heart disease (p=0.245), baseline mitral regurgitation (p=0.208), aortic regurgitation (p=0.389), or left ventricular dysfunction (p=0.850).

Table 1. Baseline patient characteristics

Variable	Value
Age	80.8±6.5
Female n (%)	33 (55)
Atrial fibrillation n (%)	16 (26.7)
Ischemic heart disease n (%)	48 (80)
Pacemaker after TAVI n (%)	29 (48.3)
Mitral regurgitaion (pre)	Moderate to severe 19 (31.7)
Mitral regurgitaiton (post)	Moderate to severe 18 (30)
Aortic regurgitation (post)	Moderate to severe 10 (16.7)
LV dysfunction pre	Mild to severe 20 (33.3)
LV dysfunction post	Mild to severe 22 (36.7)

TAVI: Transcatheter aortic valve implantation, LV: Left ventricular

Figure illustrates the distribution of selected post-procedural complications stratified by pacemaker status. Although not statistically significant, the PPI group showed numerically higher rates of post-TAVI mitral and aortic regurgitation.

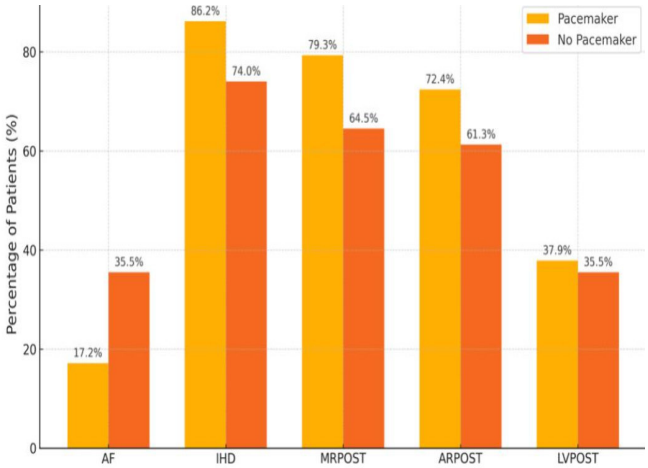

Figure. Distribution of clinical variables by pacemaker status

Bivariate analysis did not identify any single clinical or echocardiographic variable as a statistically significant predictor of PPI (**Table 2**). These findings suggest that conventional baseline risk factors may have limited value in forecasting the need for PPI following TAVI in this cohort.

DISCUSSION

In this retrospective analysis of 60 patients undergoing transfemoral TAVI, we found that nearly half (48.3%) required PPI, a rate considerably higher than typically reported in

Table 2. Bivariate analysis of groups

Variable	Pacemaker (n=29)	No pacemaker (n=31)	p value
Age (years)	81.4±6.5	80.2±6.5	0.533[1]
Female n (%)	17 (58.6)	16 (51.6)	0.586[2]
Atrial fibrillation n (%)	5 (17.2)	11(35.5)	0.110[2]
Ischemic heart diseasen (%)	25 (86.2)	23 (74)	0.245[2]
LV dysfunction after TAVI n (%)	11 (37.9)	11 (35.5)	0.850[2]
Mitral regurgitation (psot). %	23 (79.3)	20 (64.5)	0.208[2]
Aortic regurgitation (psot). %	21 (72.4)	19 (61.3)	0.389[2]

TAVI: Transcatheter aortic valve implantation, LV: Left ventricular

contemporary series. Despite examining a broad range of clinical and echocardiographic parameters, no statistically significant predictors of PPI were identified. These findings highlight the multifactorial and, in many cases, unpredictable nature of conduction disturbances following TAVI.

Our PPI rate aligns with early experiences using first-generation self-expanding CoreValve devices, which have been consistently associated with higher rates of conduction abnormalities and subsequent pacemaker implantation. Data from the CoreValve U.S. Pivotal trial reported a 30-day PPI rate of approximately 22.3%, which increased with longer follow-up.[8] Similarly, the FRANCE-2 registry showed a 26.7% PPI rate for CoreValve compared to only 6.1% for balloon-expandable Edwards SAPIEN valves.[9] The deeper implantation and subannular extension of self-expanding prostheses are thought to contribute to this elevated risk by exerting mechanical pressure on the atrioventricular conduction axis, particularly the bundle of His.

Despite this well-established anatomical rationale, the identification of consistent clinical predictors remains elusive. In our cohort, variables such as age, sex, atrial fibrillation, left ventricular dysfunction, and valvular regurgitation did not correlate significantly with the need for PPI. This is in agreement with findings from Khawaja et al.,[3] who showed that baseline clinical variables had limited predictive value for post-TAVI PPI and emphasized the role of procedural and anatomical factors, such as implantation depth and membranous septum length. Similarly, a meta-analysis of 2.707 patients found no strong association between baseline clinical variables and PPI risk. Instead, anatomical and procedural factors—such as short membranous septum length, deeper implantation depth, and annular/leaflet calcification—were significantly associated with increased PPI rates.[10]

The lack of procedural detail in our study, such as implantation depth or pre-existing conduction abnormalities (e.g., PR interval, QRS duration, RBBB), limits our ability to assess these potentially crucial risk factors. Moreover, the high PPI rate may partly reflect institutional learning curves and the use of early-generation TAVI systems, which have since undergone significant technical refinements. Newer-generation devices like the Evolut PRO and SAPIEN 3 have demonstrated reduced PPI rates due to improved valve profiles and more precise deployment mechanisms.[11,12]

Clinical implications of PPI after TAVI remain a subject of ongoing debate. Several studies suggest that PPI may be associated with adverse long-term outcomes such as increased heart failure hospitalization, impaired left ventricular function, and higher mortality, particularly in pacing-dependent individuals.[13,14] However, other investigations have not confirmed these associations, underscoring the heterogeneity of this population and the need for individualized pacing strategies.[15,16]

From a clinical standpoint, our findings support the notion that traditional preprocedural variables alone are insufficient for accurate risk stratification. As Oestreich et al.[17] suggested, integrating multimodal imaging—including CT-based assessment of the membranous septum and aortic root orientation—with ECG markers may enhance prediction models and guide intra-procedural decision-making. Furthermore, procedural strategies such as high implantation techniques and cusp-overlap views have shown promise in reducing conduction system trauma and should be considered in centers aiming to minimize PPI burden.[18]

Limitations

This study has several important limitations. First, the retrospective and single-center nature of the analysis, coupled with a relatively small sample size (n=60), restricts the statistical power to identify subtle but clinically relevant associations. Second, the data represent an early era of TAVI, with procedures performed between 2008 and 2011 using first-generation CoreValve devices. Given the substantial evolution in valve technology and implantation techniques over the past decade, the applicability of our findings to contemporary practice—characterized by newer-generation devices and refined procedural strategies—may be limited.

Third, the study lacked access to key procedural parameters, including implantation depth, valve-to-annulus oversizing ratio, and fluoroscopic views such as cusp-overlap techniques, all of which are known to impact conduction system outcomes. Furthermore, pre-existing conduction disturbances (e.g., PR interval, QRS duration, RBBB) were not systematically documented, and electroanatomical mapping was not utilized. These omissions precluded a more granular analysis of ECG predictors of PPI.

Finally, the study did not assess long-term clinical outcomes such as pacing dependency, heart failure hospitalizations, cardiovascular mortality, or functional recovery. These factors are critical to understanding the true prognostic implications of post-TAVI permanent pacing. Taken together, these limitations highlight the need for future prospective, multicenter investigations incorporating standardized procedural protocols, advanced imaging modalities, and extended clinical follow-up.

CONCLUSION

PPI remains a common complication after TAVI, particularly with early-generation self-expanding valves. No single clinical or echocardiographic predictor was identified in our cohort, reflecting the multifactorial nature of conduction disturbances. Future research should focus on integrating

detailed imaging and procedural data to improve risk stratification and reduce unnecessary pacemaker use as TAVI technology evolves.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of the Ethics Committee of Mogadishu Somalia Turkiye Recep Tayyip Erdoğan Training and Research Hospital (Date: 09.04.2025, Decision No: 1197).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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